This document contains Part 2 (pp.84–99) of Chapter 3 of the National Coastal Condition Report III.

The entire report can be downloaded from http://www.epa.gov/nccr

National Coastal Condition Report III

Chapter 3: Northeast Coast Coastal Condition

Part 2 of 3

December 2008

Fish Tissue Contaminants Index

The fish tissue contaminants index for the Northeast Coast region is rated poor based on concentrations of chemical contaminants found in composites of whole-body fish and lobster specimens. Thirty-one percent of the fish samples analyzed were rated poor, and 28% were rated fair (Figure 3-8). Although this figure gives an accurate indication of where fish or lobster specimens with appreciable contaminant levels were collected, several associated factors should be carefully considered before relating these findings to human risk or to the evaluation of coastal condition. For example, one factor that should be considered is the species of fish analyzed because different tissue types have different affinities for specific contaminants and these differences are likely to be species dependent. Currently, detailed information regarding these affinities is sparse. To improve understanding, NCA sampling and analysis protocols were altered in subsequent years to analyze "split samples" (i.e., samples of edible portions of fish and lobster are analyzed separately from inedible portions, and lobster hepatopancreas [tomalley] is also analyzed separately from the other tissues). In addition, it is helpful to consider the habits of the fish species collected when interpreting results. For instance, knowing the migration patterns of a fish species may help researchers determine the source of the contaminants measured in fish tissue.

Elevated concentrations of PCBs were responsible for the fair or poor ratings for a large majority of specimens, although other contaminants, such as DDT or mercury, were also implicated. Based on preliminary information from the split-sample study mentioned above, only those contaminants (e.g., mercury) that have an affinity for muscle tissue are likely to have significantly higher concentrations in fillets than in whole fish; concentrations for many other contaminants will be lower in fillets than in whole-fish samples. NCA data suggest that there may be a pronounced gradient increasing from north to south in the incidence of contamination; however, distinct differences also existed in the types of organisms caught and analyzed across the region (e.g., primarily lobster in Maine versus fish such as white perch and summer flounder farther south). It may be the case that cadmium was preferentially accumulated in lobster, although not to concentrations that exceeded Guidance levels. PCBs and DDT were the contaminants most frequently exceeding Guidance levels, with the highest concentrations measured in white perch and summer flounder. Further research is needed to understand the relative importance of the species and tissue affinity for contaminants versus the availability of the contaminants.

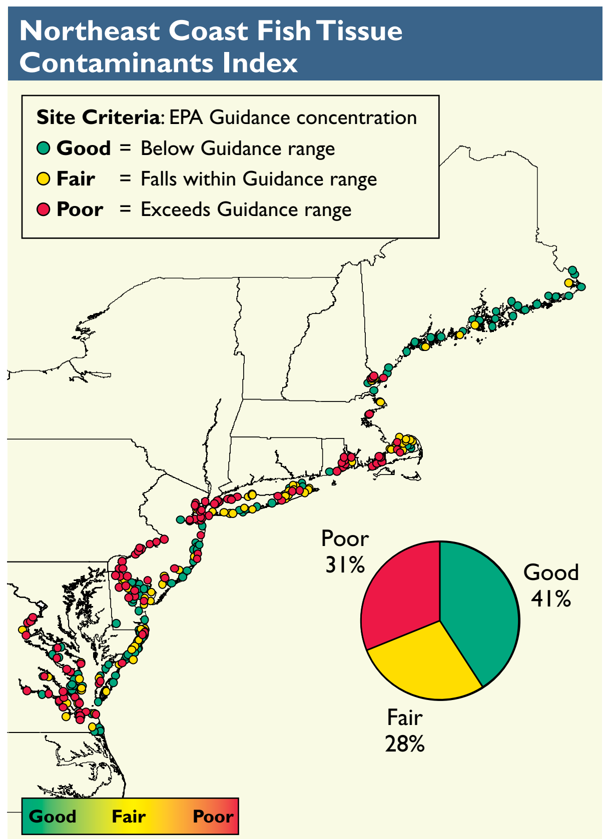


Figure 3-8. Fish tissue contaminants index data for Northeast Coast coastal waters (U.S. EPA/NCA).

Trends of Coastal Monitoring Data—Northeast Coast Region/Virginian Province Subset

Temporal Change in Ecological Condition

Beginning in the early 1990s, EPA and its partners conducted a series of monitoring programs to assess the ecological condition of the nation's coastal waters. A hallmark of the various programs was consistency, both in the probabilistic nature of the sampling designs (sites were selected at random to represent all coastal waters) and in the fact that all programs used a core set of parameters that were measured with equivalent protocols and QA/QC procedures. This consistency eases the task of tracking changes over time. The following sections analyze these data to answer two trend-related questions for the Northeast Coast region: what is the year-to-year variability evident in the proportions of the region's coastal area rated in good, fair, and poor condition, and are there significant changes in the area classified as poor during the period from 1990 to 2001?

Several monitoring programs have assessed portions of the Northeast Coast region since the early 1990s, including the Environmental Montoring and Assessment Program-Virginian Province (EMAP-VP), Mid-Atlantic Integrated Assessment (MAIA), Maryland Coastal Bays Program, and NCA. Details regarding these assessments are described in the following text box. Only common regions, indices, and component indicators measured by these programs over two time periods were considered. The trend analysis for the coastal waters north of Chesapeake Bay, through and including southern Cape Cod, compares conditions measured in 1990–1993 with those assessed a decade later in 2000–2001. The trend analysis is based on EMAP and NCA probability survey data restricted to the Virginian Province, exclusive of Chesapeake Bay. Core parameters measured consistently in these studies include dissolved oxygen, water clarity, sediment contaminants, sediment toxicity, sediment TOC, and benthic condition. Results for both periods were expressed as the percentage of coastal area rated good, fair, or poor based on the parameters assessed. Standard errors for these estimates were calculated according to methods listed on the EMAP Aquatic Resource Monitoring Web site (http://www.epa.gov/nheerl/arm). The reference values and guidelines outlined in Chapter 1 were used to determine good, fair, or poor condition for each indicator from both time periods.

The trend analysis results discussed in this section are restricted to a subset of the Virginian Province monitoring results from probability surveys. More detailed trend analyses can be done in estuaries with established long-term monitoring programs (e.g., in relation to hypoxia in Chesapeake Bay, reported on by Hagy et al. [2004]).

In this analysis, water quality is represented by two parameters: water clarity and bottom-water dissolved oxygen concentrations. Figure 3-9 indicates that poor water clarity was evident in 3% of the Northeast Coast coastal area in the early 1990s and was evident in 4% of the coastal area in 2000 and 2001. There were no persistent year-to-year trends of improvement or degradation, and there was no significant difference between the 1990–1993 and 2000–2001 averages.

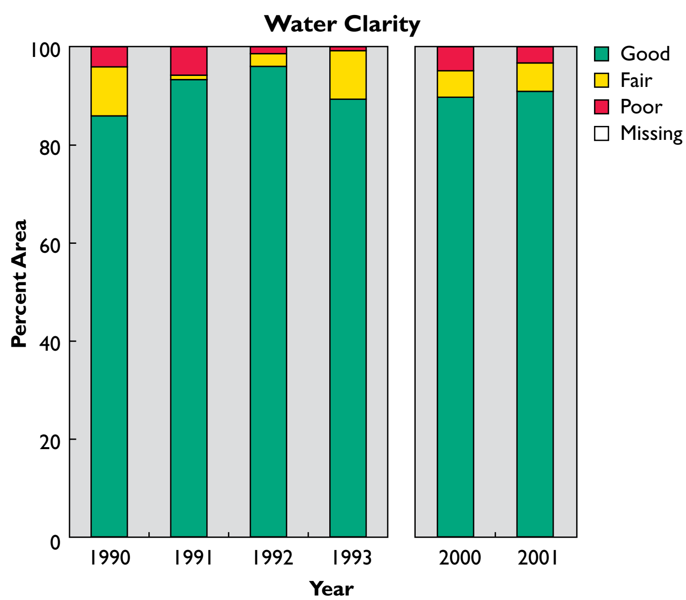


Figure 3-9. Percent area of Northeast Coast coastal waters in good, fair, poor, or missing categories for water clarity measured over two time periods, 1990–1993 and 2000–2001 (U.S. EPA/NCA).

Programs, Parameters, and Time Periods Considered in the Northeast Coast Trend Analysis

Since the early 1990s, four monitoring programs have assessed portions of Northeast Coast coastal waters using similar sampling designs and measurement protocols. For reasons outlined below, data from only two of these programs were used in analyzing trends in the Northeast Coast region over time. The contributing programs are the EMAP-VP (1990–1993) and the NCA (2000–2001). Interannual variability in a variety of parameters common to both EMAP-VP and NCA are summarized and used to help identify changes between these two time periods.

In the Northeast Coast region, the EMAP-VP project measured conditions in the Virginian Province (Cape Cod through Chesapeake Bay) each summer from 1990 through 1993. Core parameters measured included dissolved oxygen, water clarity, sediment contaminants, sediment toxicity, sediment TOC, and benthic condition. No other water quality indicators, such as chlorophyll *a* or nutrient concentrations, were measured. Results of the EMAP-VP survey were reported by Paul et al. (1999) and in the NCCR I (U.S. EPA, 2001c).

The Delaware and Maryland Coastal Bays were assessed in the summer of 1993 using EMAP methods, and the results were reported in *Assessment of the Ecological Condition of the Delaware and Maryland Coastal Bays* (Chaillou et al., 1996). These data were not included in this trend analysis because they represent a small fraction of the Northeast Coast region, and these bays were assessed independently in the EMAP-VP study.

The MAIA evaluated the coastal waters from Delaware Bay south through Albemarle-Pamlico Estuarine System during the summers of 1997 and 1998. All core indicators listed above were measured, along with several additional water quality parameters. Results were presented in the report *Condition of Mid-Atlantic Estuaries* (U.S. EPA,1998a) and were also included in the NCCR I. Because of the limited overlap of the MAIA study area and Northeast Coast region considered here, MAIA data were not included in the trend analysis.

The NCA sampled all waters in the Northeast Coast region (Maine through the Delmarva Peninsula, with the exception of Block Island and Nantucket sounds) during the summers of 2000 and 2001, and portions of the region in 2002 and later. Conditions were evaluated using the EMAP core indicators listed above, as well as additional water quality parameters, such as chlorophyll *a* and nutrient concentrations. Assessment of the data collected in 2000 was reported in the NCCR II (U.S. EPA, 2004a), and data from 2001 and 2002 are assessed in this current report (NCCR III). It should be noted that NCA data from 2002 were excluded from the trend analysis because they were only collected from portions of the Northeast Coast region.

Only portions of Chesapeake Bay were monitored by the NCA survey in 2000 and 2001. The assessment of 2000 data, reported in NCCR II, utilized data from the CBP (http://www.chesapeakebay.net) to evaluate water quality and benthic quality, and MAIA 1997–1998 data were used to assess sediment quality for the Bay. A similar approach is used in the current report (NCCR III), which includes water quality and benthic community data sampled in 2001 and 2002 from the CBP, along with 1998–2001 sediment quality data from NOAA. Because of the different sampling designs and time periods for documenting Chesapeake Bay conditions, Chesapeake Bay was excluded from the trend analysis.

In summary, the data considered in the trend analysis for the Northeast Coast region were limited to estuaries and coastal embayments from southern Cape Cod through the Delmarva Peninsula that were sampled using data from consistent sampling designs for two time periods: 1990–1993 and 2000–2001. Indicators measured consistently in these studies include dissolved oxygen, water clarity, sediment toxicity, sediment contaminants, sediment TOC, and benthic condition.

Figure 3-10 shows the percentage of the Northeast Coast coastal area rated good, fair, or poor for dissolved oxygen during the periods 1990–1993 and 2000–2001. On average, 83% of the region's coastal area had adequate dissolved oxygen levels in the early 1990s, and less than 1% of the area was rated poor for this component indicator. In the 2000–2001 time period, dissolved oxygen levels were rated good in 73% of the coastal area and poor in 4% of the area. The year-to-year variation in dissolved oxygen concentrations is large, and the differences between the two time periods are not significant.

For the Virginian Province data subset being used in this trend analysis, the condition of coastal sediments was evaluated using three component indicators: sediment toxicity, sediment contaminants, and sediment TOC; however, the overall sediment quality index was not compared. Approximately 9% of the coastal area was rated poor for sediment toxicity during each time period (Figure 3-11). Figure 3-12 indicates that the proportion of coastal area rated fair or poor for sediment contaminants is variable and showed no significant trends. For example, 7% of the coastal area was rated poor and 18% was rated fair in 1990–1993 as compared to 12% rated poor and 17% rated fair in 2000–2001. Figure 3-13 shows that less than 2% of the Northeast Coast region's coastal area had excessive concentrations of TOC in sediments, and comparable areas were classified as fair for this indicator.

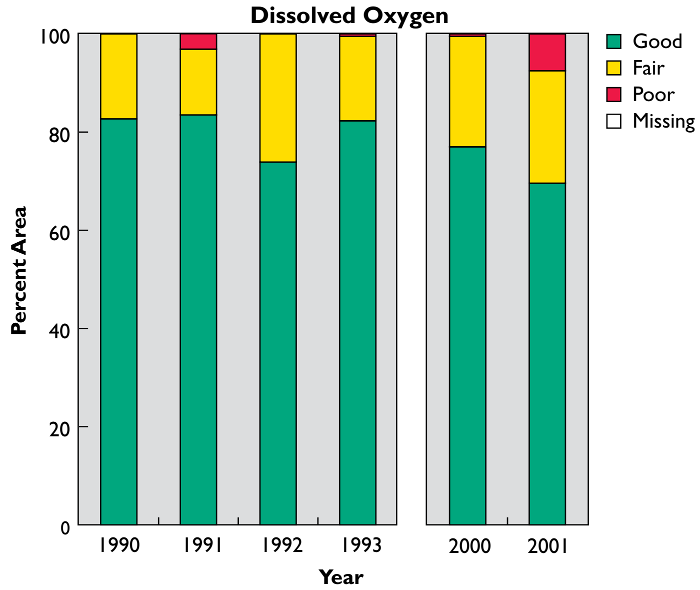


Figure 3-10. Percent area of Northeast Coast coastal waters in good, fair, poor, or missing categories for bottom-water dissolved oxygen concentrations measured over two time periods, 1990–1993 and 2000–2001 (U.S. EPA/NCA).

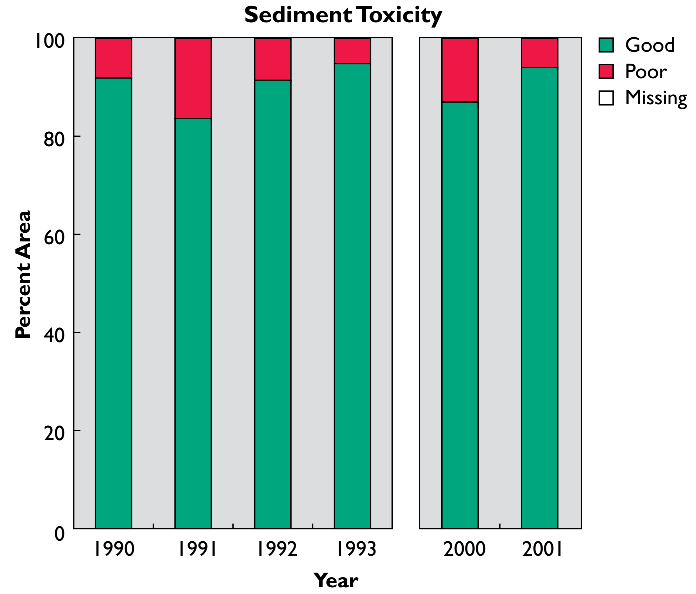


Figure 3-11. Percent area of Northeast Coast coastal waters in good, poor, or missing categories for sediment toxicity measured over two time periods, 1990–1993 and 2000–2001 (U.S. EPA/NCA).

Sediment quality can affect the health and abundances of bottom-dwelling invertebrates (courtesy of NPS).

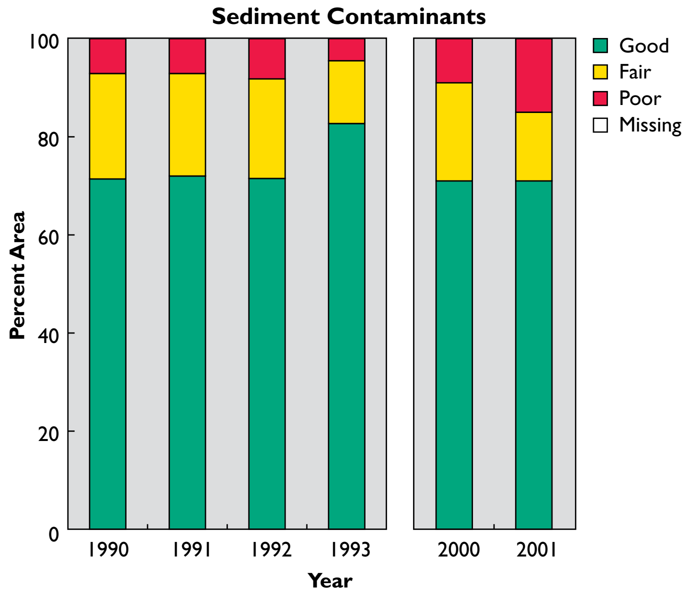


Figure 3-12. Percent area of Northeast Coast coastal waters in good, fair, poor, or missing categories for sediment contaminants measured over two time periods, 1990–1993 and 2000–2001 (U.S. EPA/NCA).

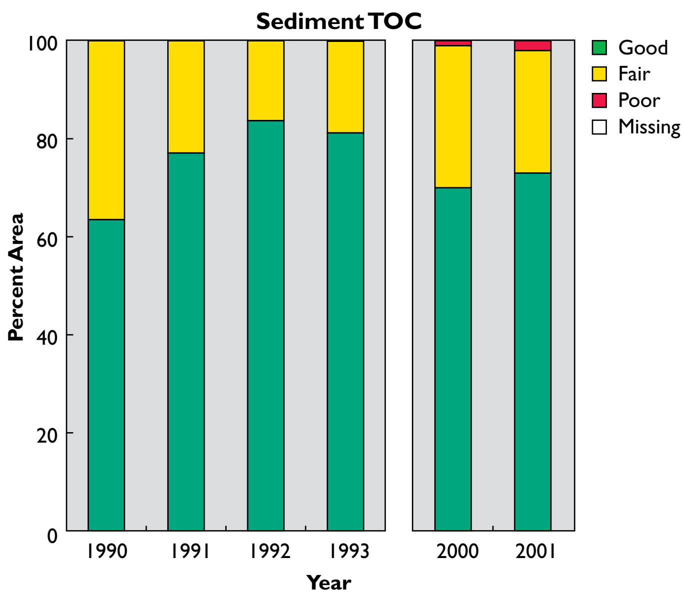


Figure 3-13. Percent area of Northeast Coast coastal waters in good, fair, poor, or missing categories for sediment TOC measured over two time periods, 1990–1993 and 2000–2001 (U.S. EPA/NCA).

The benthic index for the Northeast Coast coastal area is a multi-metric indicator of the biological condition of benthic macroinvertebrate communities. This index measures the habitability of sediments for benthic communities of high biological integrity and serves as an overall indicator of water and sediment conditions. Figure 3-14 shows a lack of detectable trend in the percent of Northeast Coast coastal area that was rated poor for the benthic index. On average, 26% of the coastal area was rated poor in 1990–1993 and 34% of the area was rated poor in 2000–2001, although the difference is not significant.

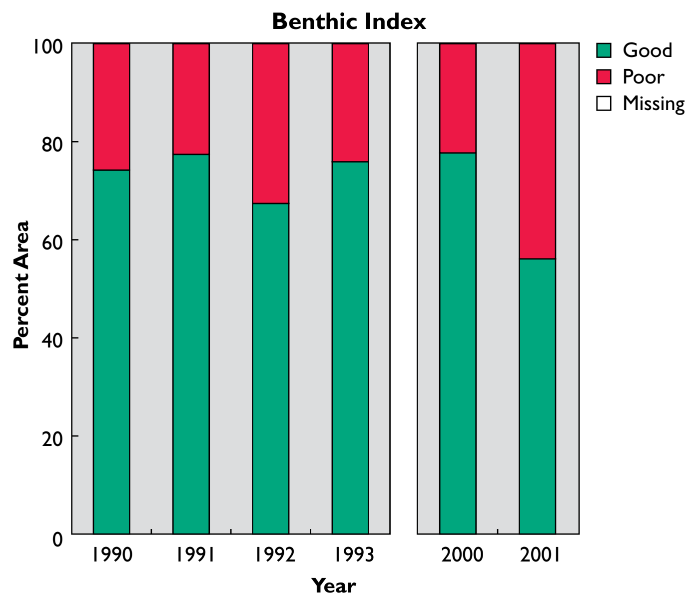


Figure 3-14. Percent area of Northeast Coast coastal waters in good, poor, or missing categories for the benthic index measured over two time periods, 1990–1993 and 2000–2001 (U.S. EPA/NCA).

Figure 3-15 summarizes changes in the percent area classified as poor in the Northeast Coast coastal area for the six common indicators measured over two time periods: 1990–1993 and 2000–2001. The error bars shown are 95% confidence intervals calculated as described at the EMAP Aquatic Resource Monitoring Web site (http://www.epa.gov/nheerl/arm). Note that for all indicators, a slightly greater percentage of coastal area is rated poor in the later time interval; however, none of the differences are significant (based on a jackknifed analysis of variance that considers variable station weighting).

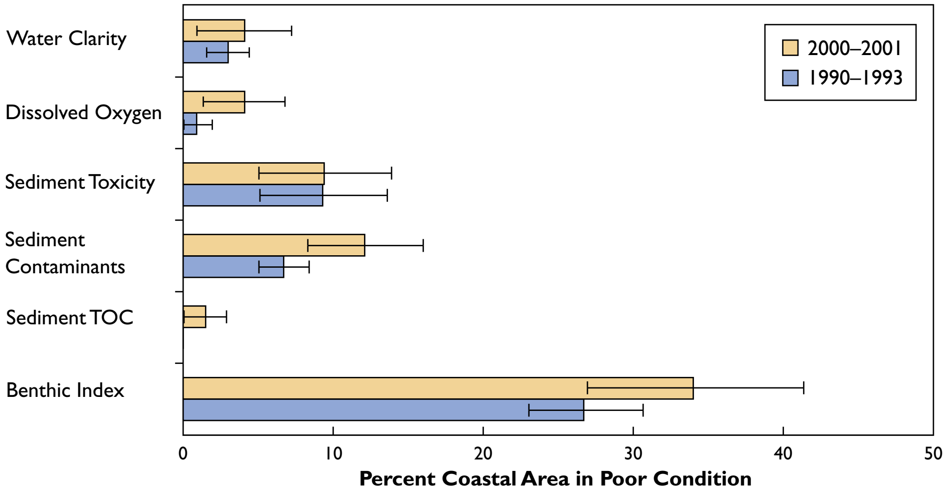


Figure 3-15. Comparison of percent area of Northeast Coast coastal waters rated poor for ecological indicators between two time periods, 1990–1993 and 2000–2001. Error bars are 95% confidence intervals (U.S. EPA/NCA).

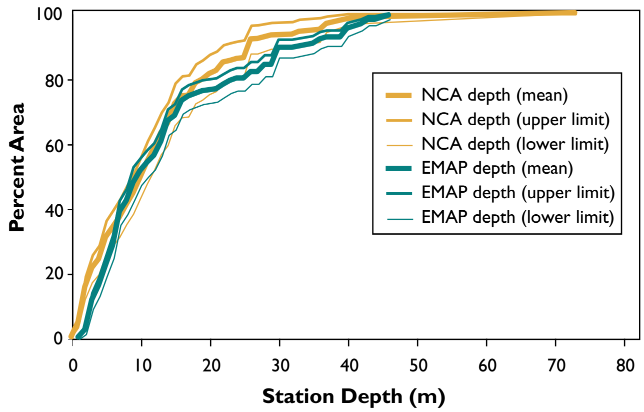


Figure 3-16. Cumulative distribution functions of station depths measured in EMAP-VP and NCA studies. Upper and lower limits are 95% confidence limits (U.S. EPA/NCA).

Although data processing was performed to compare areas where sampling overlapped geographically during the 1990–1993 and 2000–2001 time periods, comparison of other properties indicated that there were some differences between the samples from the two time periods. The cumulative distribution function (CDF) for depth indicates that similar water depths were measured by the EMAP-VP (with Block Island and Nantucket Sound samples excluded) and NCA studies; however, Figure 3-16 shows the NCA depth CDF slightly above the EMAP-VP CDF over the range of 20–30 meters, indicating a slightly higher NCA sampling frequency in this depth range. There were much larger differences in the time of year sampled for the two studies. EMAP-VP sampling started slightly later in the year, but finished earlier than the NCA sampling. In addition, there were significant differences in surface water temperature and salinity at the time of sampling. Significantly warmer temperatures were measured by the NCA than by the EMAP-VP, likely due to a higher sampling frequency later in the summer for the NCA than the EMAP-VP. The percent of the coastal area with salinities below 25 ppt was the same in both time periods; however, when the areas with salinities above 25 ppt were compared, the NCA samples exhibited slightly lower salinities.

Bowers Beach, DE, is located on the Delaware Bay (courtesy of NOAA).

Highlight

Implementing System-Wide Monitoring in the NOAA National Marine Sanctuaries

Whale watching is a popular activity in Stellwagen Bank NMS (courtesy of NOAA).

In 2004, the NOAA National Marine Sanctuary (NMS) Program launched a System-Wide Monitoring Program (SWiM) for the nation's 14 marine sanctuaries. The goal of SWiM is to provide a consistent approach to the design, implementation, and reporting of environmental condition assessments in sanctuaries, while allowing for tailored monitoring at individual sanctuary sites. The information collected by this program will contribute to and benefit from other monitoring programs, such as IOOS. Assessment reports will be developed for each sanctuary at the local level following a consistent model. The reports will serve as building blocks for the system-wide monitoring approach and allow for regional and national reports on environmental conditions at larger scales (NOAA, 2007h).

Implementation of SWiM began with the development of a guidance document (NOAA, 2004b) and a pilot assessment report (NOAA, 2007d) for one site, the Stellwagen Bank NMS, located off the Massachusetts coast. The Stellwagen Bank NMS is located 3 miles north of Cape Cod and 3 miles southeast of Cape Ann, entirely within federal waters. The pilot assessment report will serve as a model for the remaining 13 sanctuary assessments and as a means by which to answer questions about the condition of sanctuary resources. These determinations will be key to tracking the condition of marine ecosystems on the scale of individual sanctuaries, groups of sanctuaries, and system wide.

The Stellwagen Bank NMS assessment includes sections that describe sanctuary resources, pressures that threaten the integrity of the marine environment (e.g., human activities), the current state of resources, trends, and management responses to the pressures. The primary purpose of the document is to report on the status and trends of water, habitat, living resources, and archaeological resources, as well as on the human activities that affect them. Resource status is rated on a scale from poor to good, and the timelines used for comparison vary from topic to topic. Trends are generally based on observed status changes over the past 5 years and are reported as improving, declining, or not changing. Reports summarizing resource status and trends will be prepared for each marine sanctuary once every 5 years and, when possible, will coincide with the review of sanctuary management plans.

Development of the assessment report card relies on appraisal of the condition of the marine environment, using 15 questions as a guide (see figure). The questions are widely applicable across the system of marine sanctuaries and were derived from both a generalized ecosystem framework and the NMS Program mission. The role of this national framework is not to encourage the same monitoring at all sanctuaries; rather, its primary function is to apply a set of design, implementation, and reporting principles for all monitoring within the NMS Program. Completion of the process will result in a status and trends "report card" for sanctuaries at the local level that can be compiled to provide a snapshot of system-wide conditions. As report cards are updated, time series data will be developed to provide information on changes in the condition of the marine environments over time (NOAA, 2007d). For additional information about SWiM, please visit the NMS Program Web page at http://sanctuaries.noaa.gov/science/monitoring/welcome.html.

National Marine Sanctuary Assessment Report Card Format (NOAA, 2007d)

Status:

Good	Good/Fair	Fair	Fair/Poor	Poor

Trends:
▲ Improving — Not Changing ▼ Declining

#	Questions/Resources	Explanation	Trends
Water			
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?	Captures shifts in conditions arising from changing natural processes and human-induced inputs.	
2	What is the eutrophic condition of sanctuary waters, and how is it changing?	Potential overgrowth and other competitive interactions that can lead to shifts in dominance in assemblages and food webs.	
3	Do sanctuary waters pose risks to human health?	Human health concerns aroused by evidence of contamination in bathing waters or fish intended for consumption, reports of respiratory distress, and other disorders attributable to an increase in HABs.	
4	What are the levels of human activities that may influence water quality, and how are they changing?	Human activities that affect water quality, including direct discharges, nonpoint-source discharges, airborne chemicals, and results of dredging and trawling.	
Habitat			
5	What is the abundance and distribution of major habitat types, and how are they changing?	These key attributes compared with what would be expected without human impacts, such as pollution, trawling, pipelines, fish traps, and dredging.	*Each item is assigned a status color and trend symbol.*
6	What is the condition of biologically structured habitats, and how is it changing?	Places where organisms form structures (habitats) on which other organisms depend, including coral reefs, kelp beds, and intertidal assemblages.	
7	What are the contaminant concentrations in sanctuary habitats, and how are they changing?	Risks posed by contaminants within benthic formations, including soft sediments, hard bottoms, and biogenic organisms.	
8	What are the levels of human activities that may influence habitat quality, and how are they changing?	Human activities that degrade habitat quality by affecting structural, biological, oceanographic, or chemical characteristics.	
Living Resources			
9	What is the status of biodiversity, and how is it changing?	The condition of living resources based on expected biodiversity levels and the interactions between species.	
10	What is the status of environmentally sustainable fishing, and how is it changing?	Whether harvesting is occurring at ecologically sustainable levels. Important to know extraction levels and the impacts of removal.	
11	What is the status of nonindigenous species, and how is it changing?	The potential threat posed by nonindigenous species; in some cases, by presence, in others, by measurable impacts.	
12	What is the status of key species, and how is it changing?	(1) Keystone species on which the persistence of a large number of other species in the ecosystem depend, and (2) other key species, including those that are indicators of ecosystem condition or change, those targeted for special protection efforts, or charismatic species associated with certain areas or ecosystems.	
13	What is the condition or health of key species, and how is it changing?	Measures of condition of key species that are important to determining the likelihood that the species will persist and continue to contribute to a vital ecosystem.	
14	What are the levels of human activities that may influence living resource quality, and how are they changing?	Human activities that degrade living resource quality by causing a loss or reduction in species, disrupting critical life stages, impairing various physiological processes, or promoting the introduction of nonindigenous species or pathogens.	
Maritime Archaeological Resources			
15	What is the integrity of maritime archaeological resources, and how is it changing?	The apparent levels of site integrity, previous disturbance, condition of natural deterioration, and prospects for scientific investigation.	
16	Do maritime archaeological resources pose an environmental hazard, and is this threat changing?	Environmental hazards, including leakage of contents/contaminants, such as oil, in aging wrecks.	
17	What are the levels of human activities that may influence maritime archaeological resource quality, and how are they changing?	Human impacts with the potential to affect the quality of resources include looting by divers, damage caused by scuba divers, improperly conducted archaeology that does not fully document site disturbance, anchoring, groundings, and commercial and recreational fishing activities.	

Large Marine Ecosystem Fisheries—Northeast U.S. Continental Shelf LME

The Northeast U.S. Continental Shelf LME extends from the Bay of Fundy, Canada, to Cape Hatteras, NC, along the Atlantic Ocean (Figure 3-17) and is structurally very complex, with marked temperature and climate changes, winds, river runoff, estuarine exchanges, tides, and complex circulation regimes. In this temperate ecosystem, intensive fishing is the primary driving force for changes in the pounds of fish harvested, with climate as the secondary driving force. This LME has an oceanographic regime marked by a recurring pattern of interannual variability, but showing no evidence of temperature shifts of the magnitude described for other North Atlantic LMEs, such as the Scotian Shelf LME to the north (Zwanenburg et al., 2002). The Northeast U.S. Continental Shelf LME is one of the world's most productive ecosystems and has been characterized by robust average annual primary productivity (phytoplankton) and relatively stable zooplankton biomass for the past 30 years (Sherman et al., 2002). The most visible natural resource capital of the Northeast U.S. Continental Shelf LME is its rich biodiversity of fish, plankton, crustacean, mollusk, bird, and mammal species. The coastal states from Maine to North Carolina currently receive $1 billion in economic benefits annually from the fisheries of this LME (NMFS, In press).

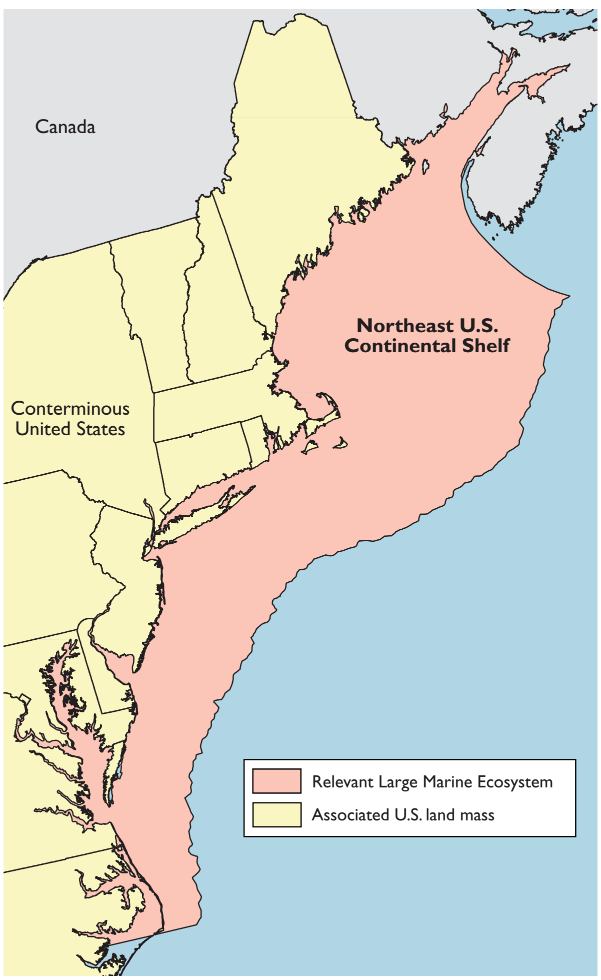


Figure 3-17. Northeast U.S. Continental Shelf LME (NOAA, 2007g).

In the late 1960s and early 1970s, intense foreign fishing within the Northeast U.S. Continental Shelf LME led to a precipitous decline in the biomass of fish stocks (NMFS, 1999). The catch of demersal (bottom-dwelling) fish stocks declined from 750,000 t in 1965 to less than 100,000 t in 1995. Significant biomass changes occurred among dominant species. For example, dogfish and skates increased in abundance in the 1970s, whereas demersal fish and flounders declined. The departure of foreign fleets in the mid-to-late 1970s was related to the 1976 Magnuson Fishing Management Act that established the 200-mile EEZ and extended U.S. jurisdiction over marine fish and fisheries. This departure, combined with management actions that reduced fishing effort in this LME, has contributed to a recovery of depleted herring and mackerel stocks and the start of a recovery of depleted yellowtail flounder and haddock stocks (Sherman et al., 2003). Long-term monitoring data on the principal prey of the pelagic fish (fish living within the water column) component of the LME shows prey biomass (total weight of prey) levels at or above a 32-year average (1972–2004) for the past 5 years (NMFS, In press).

The evidence that shows species biomass recovery following significant reduction in fishing effort through mandated actions is encouraging. Additional management efforts are underway to rebuild the depleted condition of cod, haddock, flounder, and other fish stocks to recover the economic potential of these species. With appropriate management practices, the ecosystem should provide the necessary capital in natural productivity for full recovery of depleted fish stocks (NMFS, In press).

Demersal Fish Fisheries

Northeast U.S. Continental Shelf LME demersal fish fisheries include about 35 species and stocks in waters off New England and the Mid-Atlantic states. In the New England subsystem, the demersal fish complex is dominated by members of the cod family (e.g., cod, haddock, hakes, pollock), flounders, goosefish, dogfish sharks, and skates. In the Mid-Atlantic subsystem, demersal fish fisheries include mainly summer flounder, scup, goosefish, and black sea bass (NMFS, In press).

Demersal fish resources of the Northeast U.S. Continental Shelf LME occur in mixed-species aggregations, resulting in significant bycatch interactions among fisheries directed to particular target species or species groups. Management is complex because of these interactions. This complexity is reflected, for example, in the use of different fishing gear, mesh size, minimum landing sizes, and seasonal closure regulations set by the various management bodies in the region (i.e., New England Fishery Management Council [NEFMC], Mid-Atlantic Fishery Management Council, Atlantic States Marine Fisheries Commission [ASMFC], individual states, and the Canadian government). Demersal fish fisheries in New England were traditionally managed primarily using indirect methods, such as regulating the mesh sizes of fishing gear, imposing minimum fish lengths, and closing some areas. The principal regulatory measures currently in place for the major New England demersal fish stocks are limits on the number of allowable days at sea for fishing, along with closure of certain fishing areas, trip catch limits (for cod and haddock), and targets for total allowable catch that correspond to target fishing mortality rates (NMFS, In press).

Extensive historical data for the Northeast U.S. Continental Shelf LME demersal fish fisheries have been derived from both fishery-dependent (i.e., catch and effort monitoring) and fishery-independent (e.g., NOAA research vessel surveys) sampling programs since 1963. The boundaries of the Northeast U.S. Continental Shelf LME and its subareas are depicted in Figure 3-18. Since 1989, a sea-sampling program has been conducted aboard commercial fishing vessels to document vessel discard rates and to collect high-quality, high-resolution data on their catch. Despite the past management record, some of the Northeast U.S. Continental Shelf LME demersal fish stocks (e.g., cod, yellowtail flounder, haddock, American plaice, summer flounder) are among the best understood and assessed fishery resources in the country (NMFS, In press).

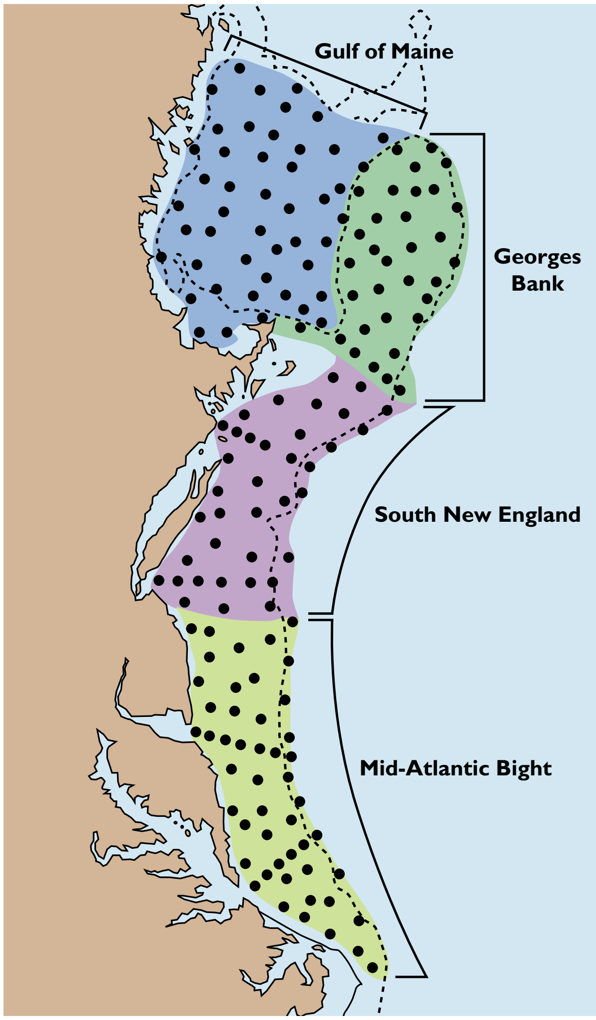


Figure 3-18. Northeast U.S. Continental Shelf LME subareas and sampling locations (Sherman et al., 2002).

In the Northeast U.S. Continental Shelf LME, fishing pressure is the primary driving force for changes in the pounds of fish harvested (courtesy of Patricia A. Cunningham).

Principal Demersal Fish Group

The principal demersal fish group of the Northeast U.S. Continental Shelf LME includes important species of cod (e.g., Atlantic cod, haddock, silver hake, red hake, white hake, pollock), flounders (e.g., yellowtail, winter, witch, windowpane, Atlantic halibut, American plaice), ocean pout, and redfish. Recent yield of these 14 species (representing 19 stocks) in this LME has averaged 81,000 t, of which 74% were U.S. commercial, 16% were Canadian, and 10% were U.S. recreational. The recent average yield is less than the combined maximum sustainable yield of about 222,000 t for these species (Figure 3-19) because many of these stocks are considered overfished and are currently rebuilding. Total ex-vessel revenue (amount the commercial fishermen receive from the quantity of fish landed) from the principal demersal fish group in 2003 was $123 million, compared to $121 million in 2000 and $109 million in 1997 (NMFS, In press). Northeast U.S. Continental Shelf LME demersal fish stocks also support important recreational fisheries for summer flounder, Atlantic cod, winter flounder, and pollock.

The research vessel survey abundance index for the principal demersal fish group has fluctuated over time and declined by almost 70% between 1963 and 1974 (Figure 3-19). This decline reflects substantial increases in exploitation associated with the advent of foreign distant-water fleets, which operate for extended periods of time in waters far from the ship's port of origin. Many stocks in this group declined sharply during that period, notably the Georges Bank haddock stock and most silver and red hake and flatfish stocks. The abundance index for the principal demersal fish group partially recovered during the mid-to-late 1970s because of the reduced fishing effort associated with increasingly restrictive management. The cod and haddock abundance indices increased markedly, pollock stock biomass increased more or less continually, and recruitment (addition of new generations of young fish) and the abundance index also increased for several flatfish stocks. The principal demersal fish group abundance index peaked in 1978, but subsequently declined and fell to new lows in 1987 and 1988. After reaching a 30-year low in 1992, this index has more than tripled due to stock-rebuilding efforts (NMFS, In press). The most recent changes in the principal demersal fish group abundance index are strongly influenced by the substantial biomass increases observed for redfish since 1996 in the Gulf of Maine subarea; however, the increased biomass of haddock and yellowtail flounder in the Georges Bank subarea and of cod in the Gulf of Maine has also influenced the principal demersal fish group abundance index (NEFSC, 2001; 2002).

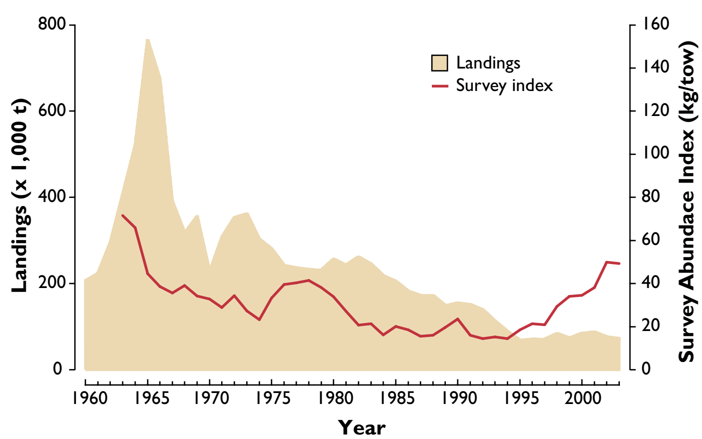


Figure 3-19. Landings in metric tons (t) and research vessel survey abundance index (kg/tow) of the principal demersal fish group, 1960–2003 (NMFS, In press).

Landings of most individual groundfish stocks declined substantially during the mid-1990s. Because of generally poor recruitment, landings of many demersal fish stocks continue to remain relatively low despite continued restrictions on days at sea; low trip limits; and additional area closures in the Gulf of Maine (NMFS, In press). However, improved stock conditions were observed for some stocks, including Georges Bank yellowtail flounder and haddock stocks. Increased landings of these two stocks have been reported since 2000 due to sharp reductions in fishing mortality combined with strong cohorts (generations of young fish from the same year) appearing in 1997 for the yellowtail flounder stock and in 1998, 2000, and 2003 for the haddock stock (NMFS, In press; NEFSC, 2002). Summer flounder spawning stock biomass in this LME has increased eight-fold over the past decade and is regulated by fishing quotas. When these quotas are attained, the fishery is shut down. Indications are that the biomasses of the scup and black sea bass stocks have also increased (NMFS, In press).

Management Concerns for Demersal Fish

During most of the 1980s and early 1990s, Northeast U.S. Continental Shelf LME demersal fish harvests were regulated by indirect controls on fishing mortality. These controls included some fishing area closures and mesh- and fish-size restrictions. These controls have been more stringent and focused since March 1994, which marked the beginning of an effort-reduction program to address the requirement to eliminate the overfished condition of cod, haddock, and yellowtail flounder stocks in this LME. The regulatory-management package included a moratorium on new vessel entrants, a schedule to reduce the number of days at sea for trawl and gill-net vessels, increases in regulated mesh size, and the expansion of closed areas to protect haddock. Since December 1994, three large areas—Closed Areas I and II on Georges Bank and the Nantucket Lightship Closed Area—have also been closed for all fishing to protect the regulated demersal fish (NMFS, In press).

A demersal fish vessel-buyout program was initiated in 1995, first as a pilot project and later as a comprehensive fishing capacity-reduction project. The program was designed to provide economic assistance to fishermen who were adversely affected by the collapse of the demersal fish fishery and who voluntarily chose to remove their vessels permanently from the fishery. This reduction in the number of vessels helped fish stocks recover to a sustainable level by reducing the excess fishing capacity in the Northeast U.S. Continental Shelf LME. The vessel-buyout program, which concluded in 1998, removed 79 fishing vessels at a cost of nearly $25 million and resulted in an approximate 20% reduction in the fishing effort in the Northeast U.S. Continental Shelf LME demersal fish fishery (NMFS, In press).

In 2004, the NEFMC increased stock-rebuilding efforts and implemented a new days-at-sea baseline that allowed only 60% of one's days at sea to be directed at regulated species in 2004 and 2005, with further reductions scheduled through 2009. The remaining 40% of days can only be used in Special Access Programs that minimize the catch of overfished stocks or in directed fishing where it can be demonstrated that bycatch of overfished stocks is minimal (NMFS, In press).

Pelagic Fisheries

The Northeast U.S. Continental Shelf LME pelagic fisheries are dominated by four species: Atlantic mackerel, Atlantic herring, bluefish, and butterfish. The abundance indices for mackerel and herring are presently above average, whereas the index for bluefish is near average and the index for butterfish is below average. During the early 1970s, the LME's two principal pelagic species (Atlantic mackerel and Atlantic herring) were exploited heavily by foreign fleets, resulting in declines in stocks and fishery yields to record-low levels by the late 1970s. Due to the exclusion of foreign fleets, the abundance indices and recruitment levels for these species have increased, leading to stock sizes that are currently at historically high levels (NMFS, In press).

The long-term trends in the abundance indices for mackerel and herring have fluctuated considerably during the past 25 years (Figure 3-20). The combined abundance index for these two species reached minimal levels in the mid-to-late 1970s, reflecting pronounced declines in stocks of both species and a collapse of the Georges Bank herring stock; however, the index subsequently increased steadily and peaked in 2001. Bottom-trawl survey abundance indices for both species have increased dramatically, with more than a ten-fold increase between the late 1970s and the late 1990s. Stock biomass of herring increased to more than 2.5 t by 1997 (NMFS, In press).

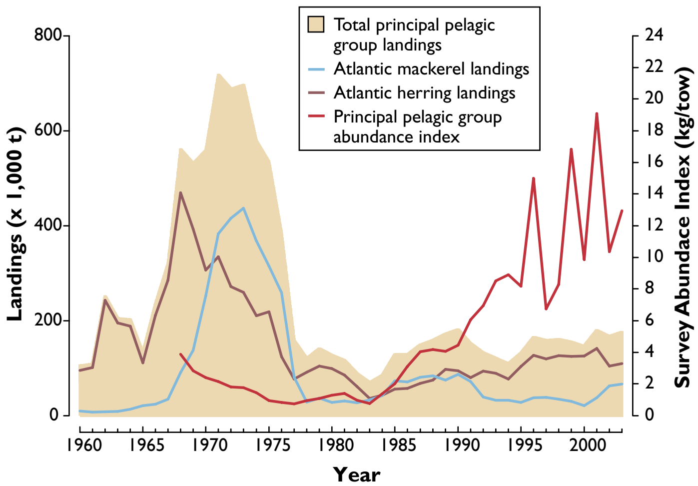


Figure 3-20. Landings in metric tons (t) and abundance indices (kg/tow) for principal pelagic stocks, 1960–2003 (NMFS, In press).

Studies of primary productivity (phytoplankton) and zooplankton biomass suggest that there are ample food resources for stocks of mackerel and herring. The zooplankton component of the Northeast U.S. Continental Shelf LME is in robust condition (Figure 3-21), with biomass levels at or above the levels of the long-term median values of the past two decades. This zooplankton community provides a suitable prey base for supporting a large biomass of pelagic fish (herring and mackerel), while also providing sufficient zooplankton prey to support strong cohorts of recovering haddock and yellowtail flounder stocks. No evidence has been found in the fish, zooplankton, temperature, or chlorophyll components to indicate any large-scale oceanographic regime shifts of the magnitude reported for the North Pacific or Northeast Atlantic ocean areas.

Although historical catch data are generally adequate for assessment purposes (except perhaps for bluefish), stock assessments for the Northeast U.S. Continental Shelf LME pelagic resources are relatively imprecise, owing to the highly variable bottom-trawl survey abundance indices used for calibrating cohort analysis models; the short life span of butterfish; and the currently low exploitation rates of mackerel and herring. The development of more precise assessments would require the use of hydroacoustic and mid-water trawl surveys to estimate herring and mackerel abundance, as well as alternative types of sampling surveys to estimate bluefish abundance. In the autumn of 1997, hydroacoustic surveys were implemented to improve stock assessments for Atlantic herring by indexing spawning concentrations. Research is underway to estimate the size of herring spawning groups directly from these survey data and to combine these estimates with data from traditional catch-at-age methods.

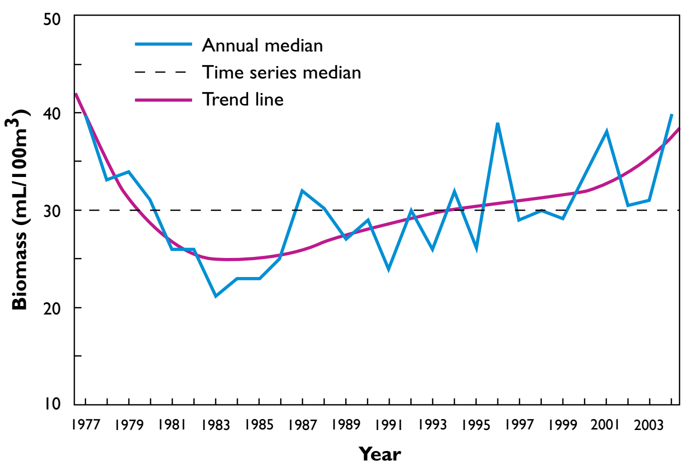


Figure 3-21. Zooplankton biomass in the Northeast U.S. Continental Shelf LME, 1977–2004 (NOAA/NMFS).

Invertebrate Fisheries

Offshore fisheries for crustacean and molluscan invertebrates are the most valuable fisheries of the Northeast U.S. Continental Shelf LME, with average ex-vessel revenues of $605 million per year during 2001–2003. The American lobster fishery ranked first in value, with average annual ex-vessel revenues of $287 million during 2000–2002 and $326 million during 2003–2004, and the Atlantic sea scallop fishery ranked second, with average annual revenues of $226 million during 2001–2003. Landings of all other offshore invertebrates (e.g., ocean quahogs, surf clams, blue mussels, squid) contributed roughly $92 million in additional revenue annually (NMFS, In press).

American Lobster

A recent assessment of American lobster stocks (ASMFC, 2000) indicated that fishing mortality rates for lobster in Gulf of Maine waters were double the overfishing level. For the inshore resource distributed from southern Cape Cod through Long Island Sound and for the offshore stock in the Georges Bank subarea, fishing mortality rates substantially exceeded the overfishing level. Throughout its range, the lobster fishery has become increasingly dependent on newly recruited animals, and commercial catch rates have markedly declined in heavily fished nearshore areas. In some locations, more than 90% of the lobsters landed are new recruits to the fishery, almost all of which are juveniles (i.e., not yet sexually mature). Fishing mortality rates for both inshore and offshore stocks presently far exceed the levels needed to produce maximum sustainable yields. Lobster landings during 1998–2000 averaged 38,100 t (with a record-high catch of 39,700 t in 1999), and during 2000–2002, landings averaged about 36,600 t. Although high fishing mortality is a persistent problem in lobster fisheries in the Northeast U.S. Continental Shelf LME, recent landings (1997–2002) are the highest observed in the period since 1940 (Figure 3-22) (NMFS, In press).

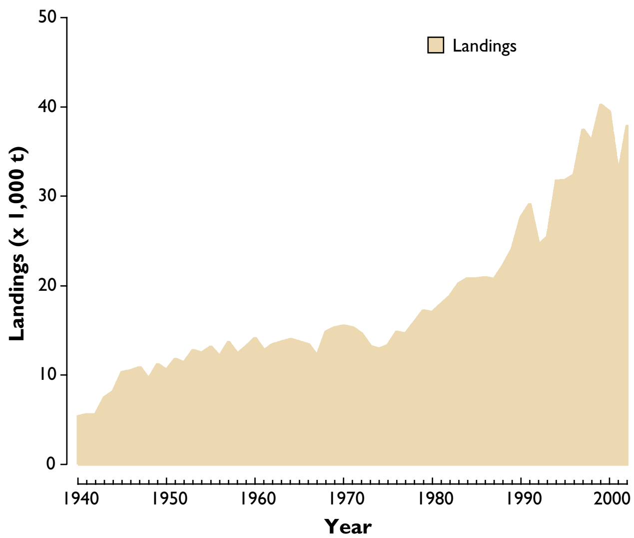


Figure 3-22. American lobster landings in metric tons (t), 1940–2002 (NMFS, In press).

Atlantic Sea Scallop

In the United States, Atlantic sea scallops are harvested in the Northeast U.S. Continental Shelf LME from Cape Hatteras, NC, to the U.S./Canadian border on Georges Bank and in the Gulf of Maine. Dredges are the principal harvesting gear, although bottom trawls take a small proportion of the landings (Serchuk and Murawski, 1997).

Management of the Atlantic sea scallop fishery changed markedly in 1994, when measures affecting the number of days at sea, vessel crew size, and dredge-ring size were implemented to address concerns about overfishing. Since December 1994, the harvesting of sea scallops in the three areas that were closed to protect demersal fish stocks has been prohibited, except under highly controlled, limited area-access provisions. In April 1998, two areas in the Mid-Atlantic Bight subarea were also closed to scallop fishing for 3 years to protect large numbers of juvenile scallops (NMFS, In press).

A recent stock assessment (NEFSC, 2001) indicated that sea scallop biomass in these closed areas increased dramatically between 1994 and 2000. Small, but substantial, increases also occurred in areas open to fishing as a result of reduced fishing effort and good reproductive success. Increases in stock biomass generated large increases in U.S. scallop landings collected in this LME (Figure 3-23) and associated revenues. Annual landings from the Northeast U.S. Continental Shelf LME averaged 25,100 t during 2001–2003 and were 29,374 t in 2004 (NMFS, In press).

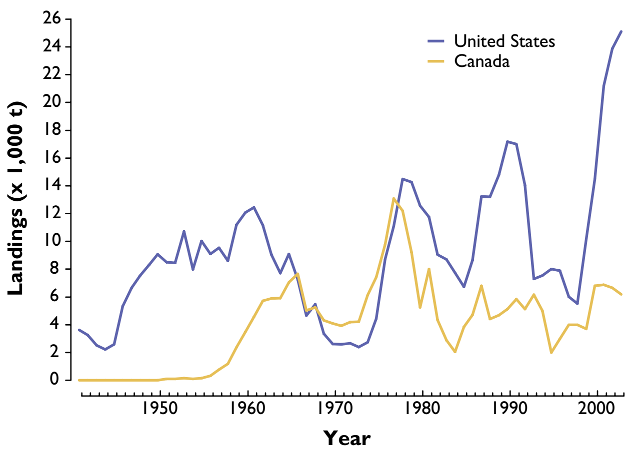


Figure 3-23. U.S. and Canadian landings in metric tons (t) of Atlantic sea scallop caught in the Northeast U.S. Continental Shelf LME, 1941–2003 (NMFS, In press).

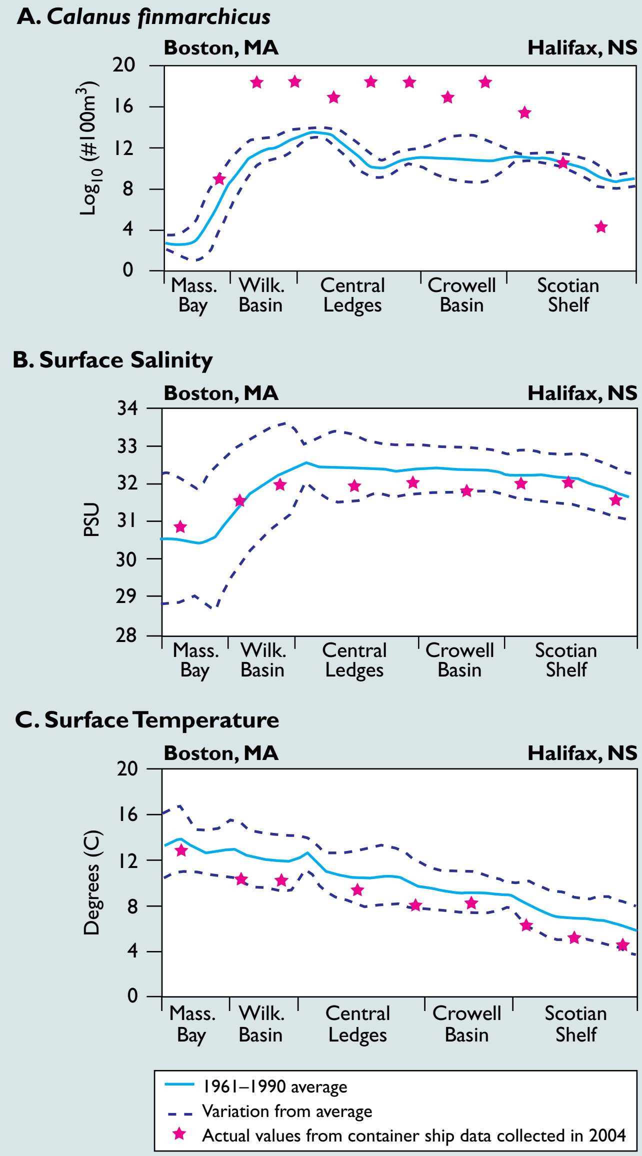
Highlight

Zooplankton Boost in the Northeast U.S. Continental Shelf LME

In 2004, NOAA scientists reported a 14-fold increase in the abundance of a key zooplankton species for waters of the Northeast U.S. Continental Shelf LME. This zooplankton species was the copepod, *Calanus finmarchicus*, which serves as prey for haddock and cod in the early stages of development, as well as for endangered right whales, which inhabit the waters of the Northeast U.S. Continental Shelf LME. Phytoplankton, which can be measured as concentrations of chlorophyll *a*, constitute a large part of the diet of *Calanus finmarchicus*, and when food is abundant, populations will increase. The boost in zooplankton abundance was linked to a drop in surface temperatures and a subsequent increase in chlorophyll *a* concentrations in the area. NOAA scientists have been employing various scientific techniques to study the relationships between surface temperatures, chlorophyll *a* concentrations, and zooplankton abundances (NOAA, 2004c).

Since 1960, scientists have employed commercial vessels to simultaneously collect data on zooplankton abundance and sea water conditions in the Northeast U.S. Continental Shelf LME. The commercial container vessels collect zooplankton population data using continuous plankton recorders (CPRs) on monthly transects between Boston, MA, and Halifax, Nova Scotia (NOAA, 2004c). Comparisons of the 2004 CPR data with the 30-year spring average (1961–1990) showed increased zooplankton populations, decreased salinity, and decreased surface water temperatures in 2004 (see figure).

Recently, scientists have paired CPR data with data obtained by NOAA's satellite-borne Advanced Very High Resolution Radiometer (AVHRR) temperature sensor and NASA's



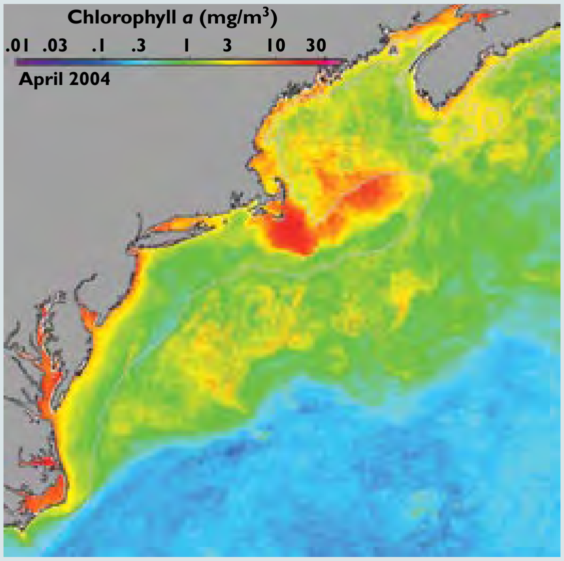
Calanus concentrations, sea surface salinity, and sea surface temperatures collected by commercial vessels traveling across the northern Northeast U.S. Continental Shelf LME (J. Jossi, NOAA/NMFS, Narragansett, RI). (A) Above average abundance of the zooplankton copepod *Calanus finmarchicus*. (B) Below average salinity. (C) Below average temperature.

Sea-viewing Wide Field-of-view Sensor (SeaWiFS) for chlorophyll to create a more robust analysis of Northeast U.S. Continental Shelf LME conditions. This combined analysis indicated that the boost in *Calanus* abundance was related to an incursion of a cold water mass into the waters of the Northeast U.S. Continental Shelf LME from the waters of the Labrador coast. The spring 2004 satellite-derived images show broad-scale chlorophyll increases and lower sea surface temperatures over the northern area of the ecosystem (see maps).

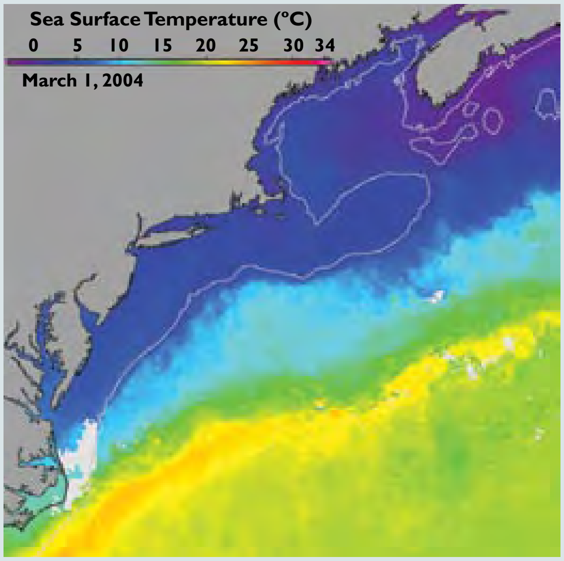
In addition, longer time-series data sets from the multi-decadal Marine Resources Monitoring, Assessment, and Prediction (MARMAP) Program provided a wider view of the path of the cold water mass. Analysis of the MARMAP database indicated that the 2004 incursion of Labrador water into the northern half of the Northeast U.S. Continental Shelf LME was related to events that occurred further north. Canadian scientists reported that the Scotian Shelf and Newfoundland-Labrador Shelf LMEs, which are located north of the Northeast U.S. Continental Shelf LME, are also under the influence of increasing incursions of cooler water from the north. These incursions may be the result of warming Arctic waters and increasing volumes of cooler, lower salinity ice-melt waters being carried southwestward into the Newfoundland-Labrador and Scotian Shelf LMEs (NOAA, 2004c).

Events such as the 2004 plankton boost provide opportunities for scientists to collect data on ecosystem variables, define potential correlations, and possibly predict future events. Marine scientists in Canada and the United States are closely monitoring the extent and volume of Labrador water incursions into the LMEs of the northwest Atlantic in an effort to better understand the impacts of cooler water on the Northeast U.S. Continental Shelf LME.

For more information, contact Kenneth Sherman at Kenneth.Sherman@noaa.gov.



Spring 2004 satellite imagery from SeaWiFS showing above average chlorophyll levels in the northern Northeast U.S. Continental Shelf LME (J. O'Reilly, NOAA/NMFS, Narragansett, RI).



Spring 2004 satellite imagery from AVHRR showing cooler than average sea surface temperatures in the northern Northeast U.S. Continental Shelf LME (J. O'Reilly, G. Wood, NOAA/NMFS, Narragansett, RI).